

Tree-ring record of hydrologic drought in the Southwest

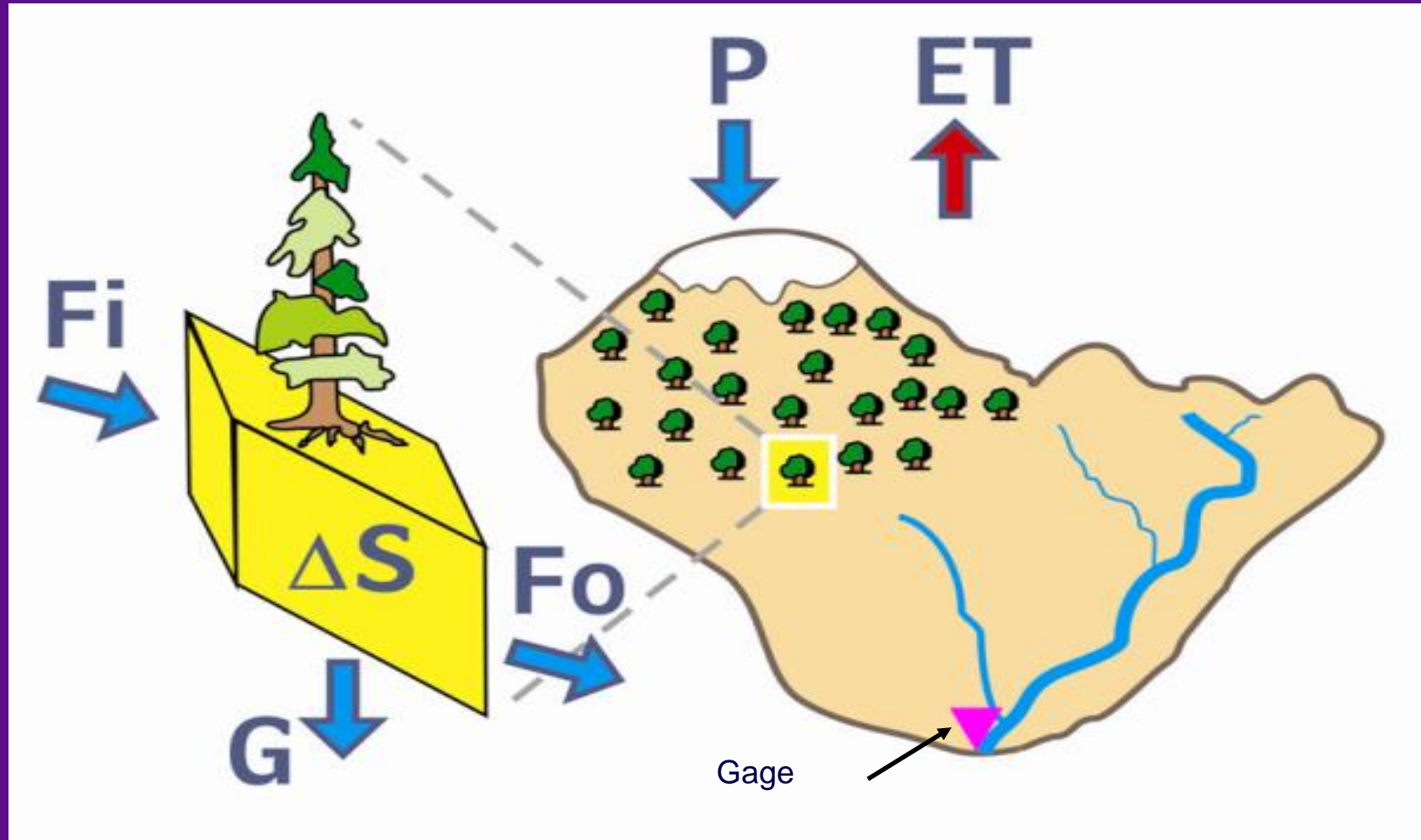


- Brief background
- SE Arizona perspective
 - Highlights of record
 - Research challenges

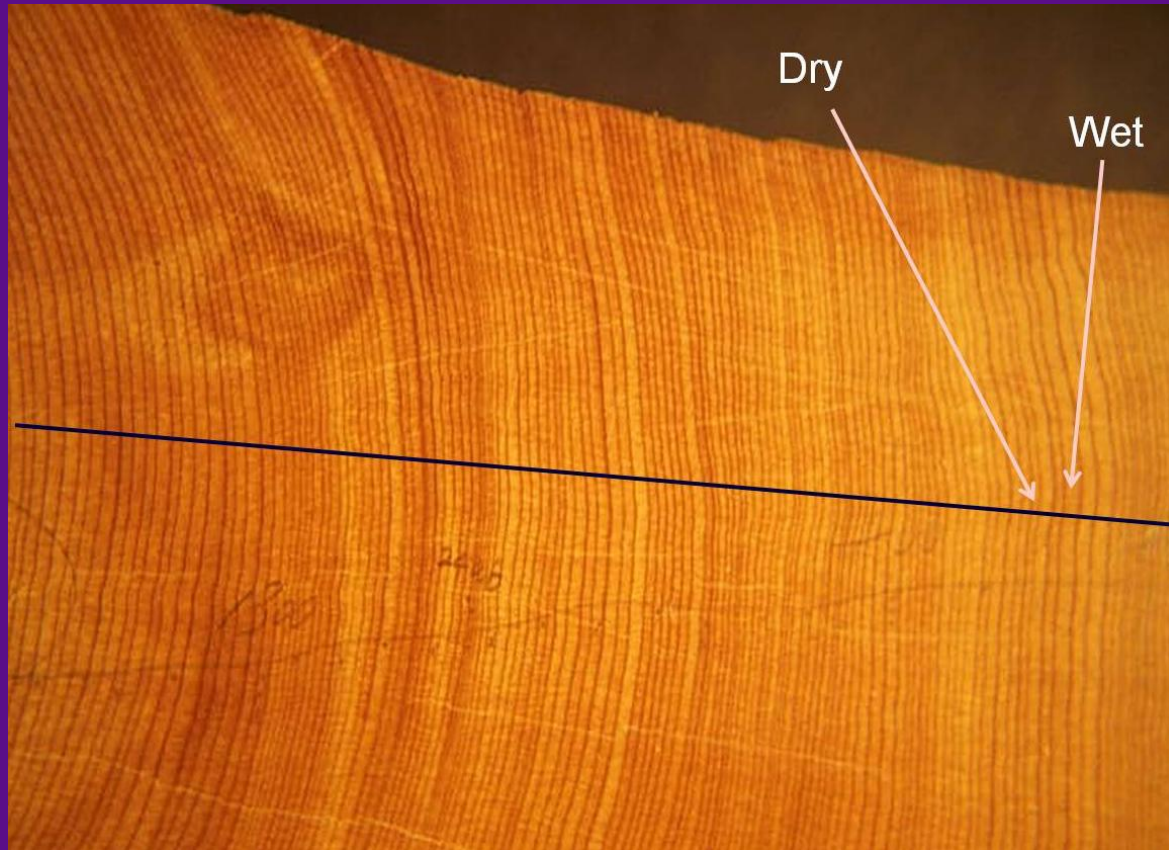
RISE Symposium, Tucson, 17 October 2015

Dave Meko
Tree-Ring Lab, U of Arizona

Hydrologic drought: deficits in soil moisture, runoff, streamflow and tree growth driven by low precipitation and high evapotranspiration



Droughts leave their imprint in measurable physical and chemical properties of the annual rings. The width of the annual ring has been widely used.



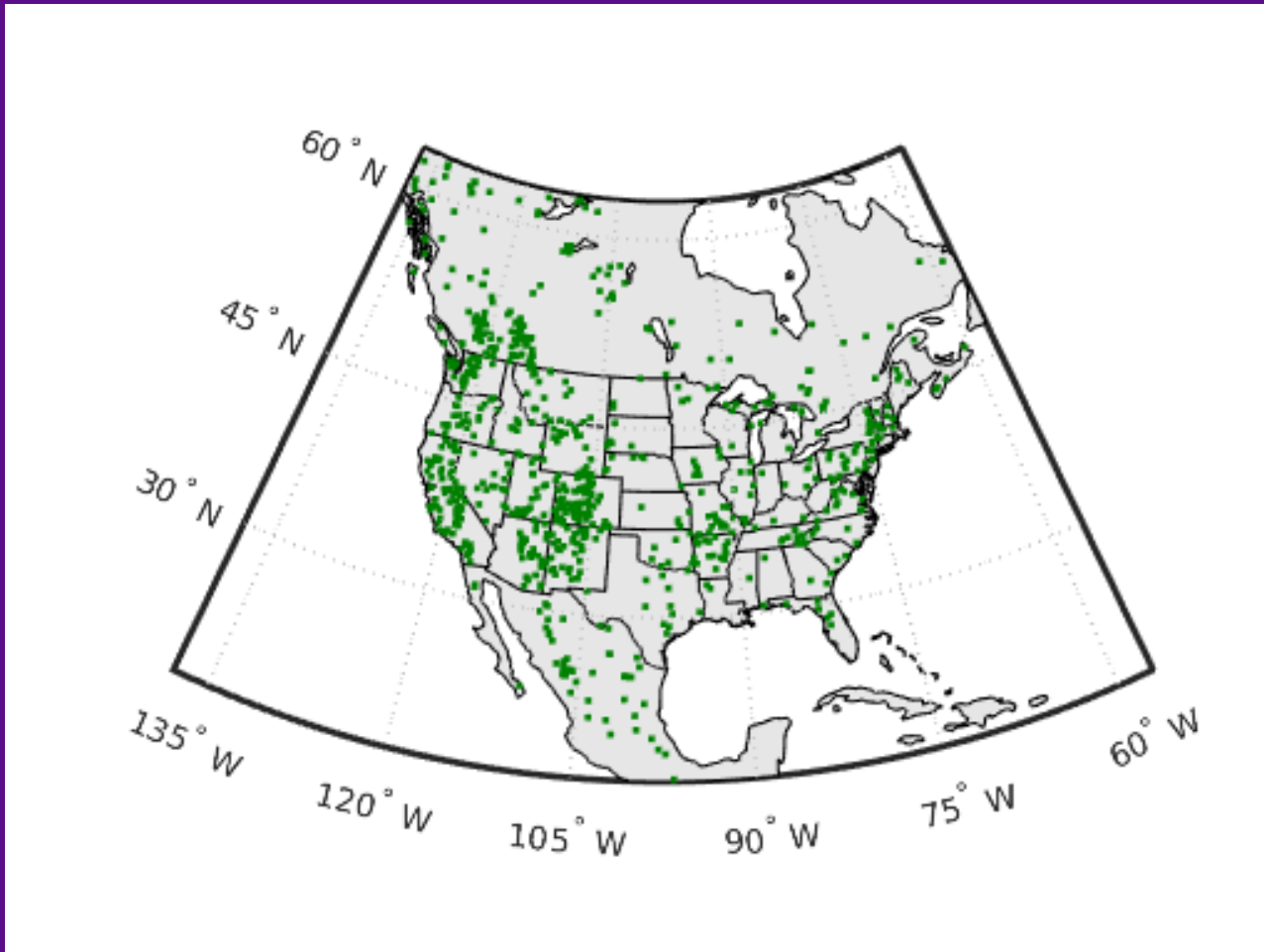
- Colorado River mid-1100s drought
- Driest 3 years in last 1200 in S California
- Snowpack in Sierra Nevada at record low
- etc

Refs 1-3 on final slide

But what about SE Arizona?



More than 900 drought-sensitive tree-ring chronologies in North America have been incorporated into the North American Drought Atlas (NADA)

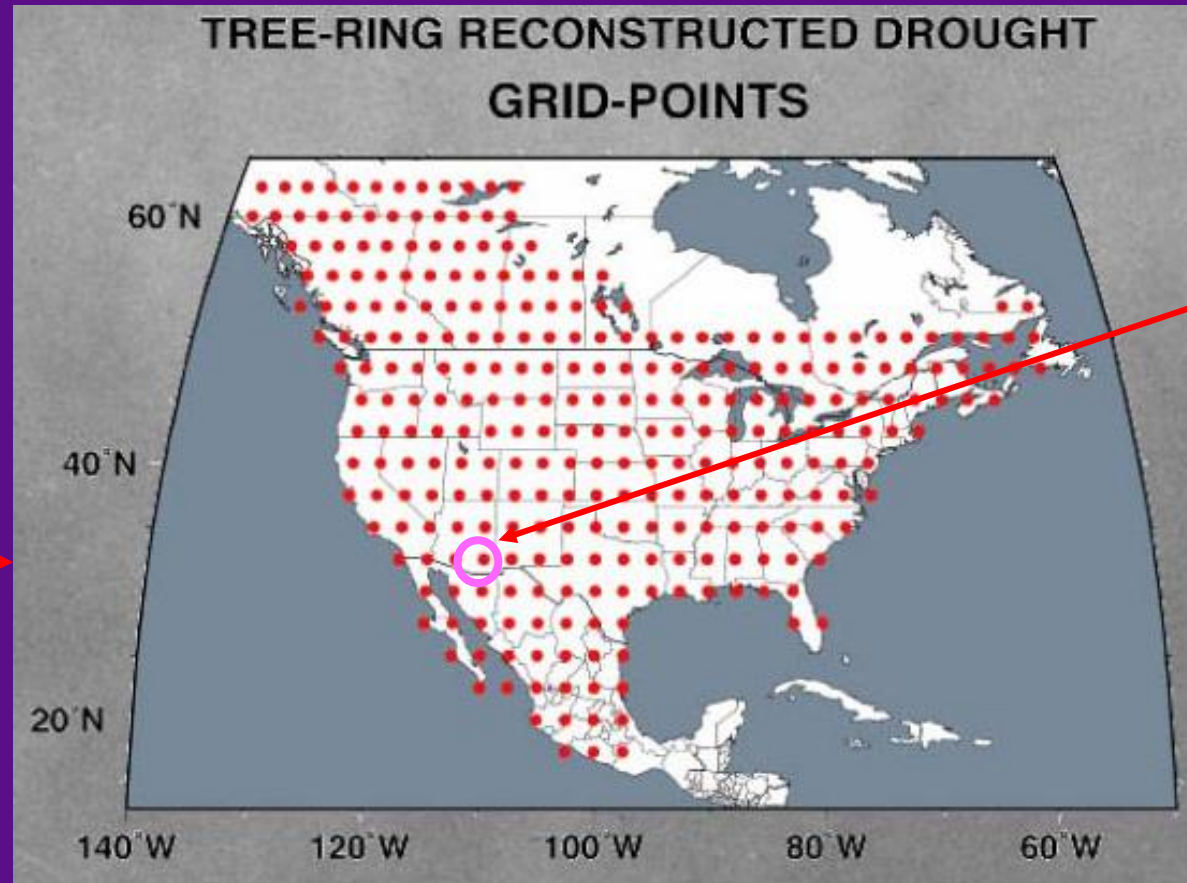


- Variable species and time coverage
- Applied to reconstruct summer (JJA) Palmer Drought Severity Index on 2.5x2.5 degree grid
- Time series and plots accessible online

Chronology locations provided by Ed Cook (ref 4)

The NADA is a valuable resource of drought information for the past 2000 years

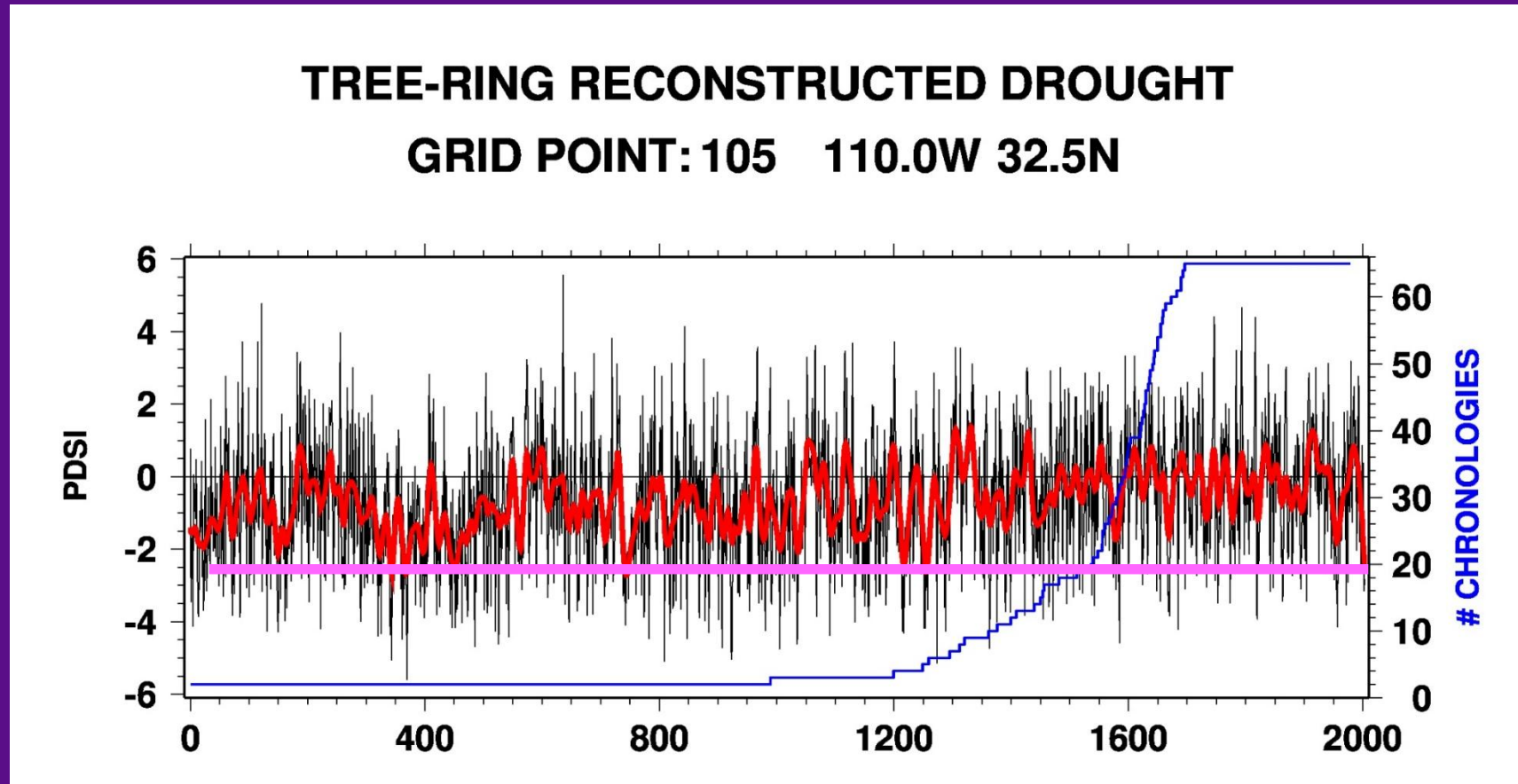
<http://iridl.ldeo.columbia.edu/SOURCES/.LDEO/.TRL/.NADA2004/.pdsi-atlas.html>



- Click on a lat/lon point
- Get plots and data

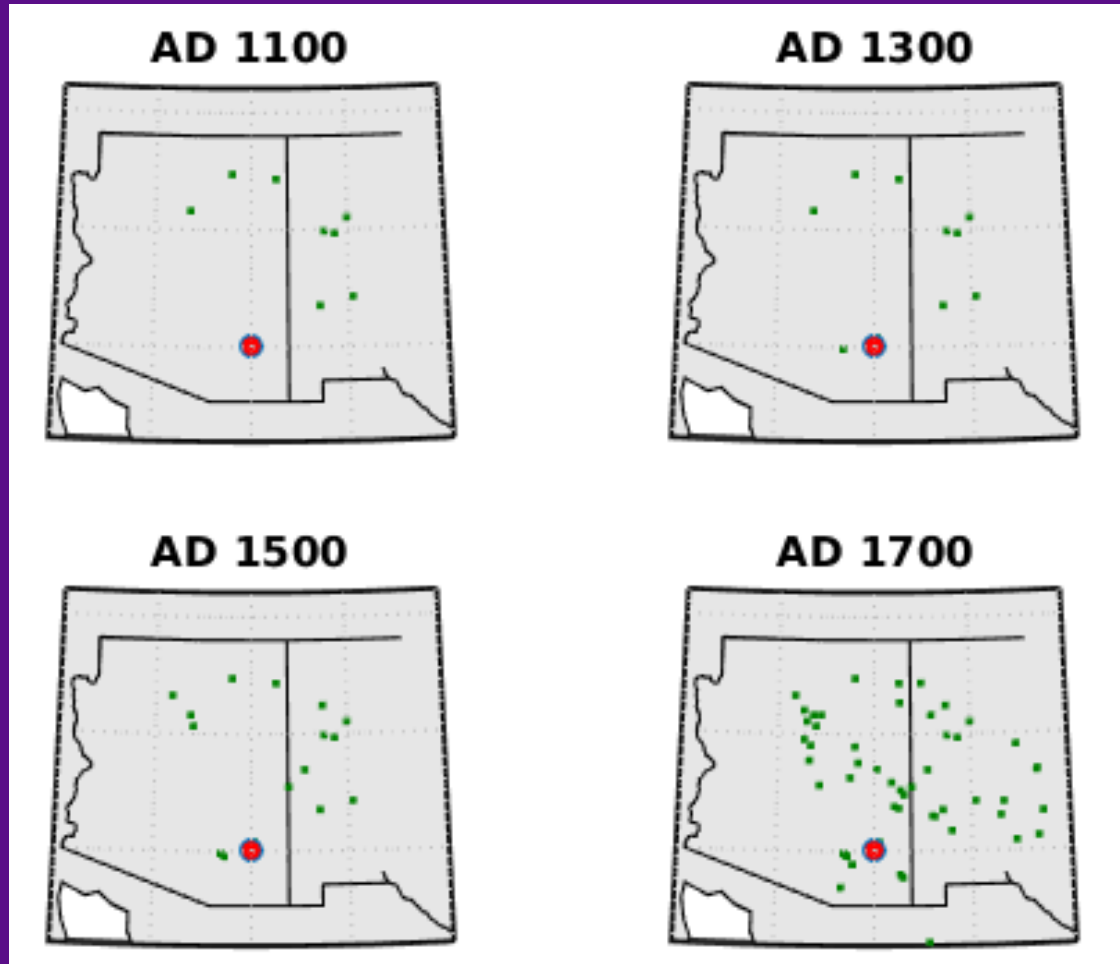
“RISE” point

At this grid point, a 10-year smoothed time series reaches a local low (dry) after 2000 unmatched at any other time since the 1200s



Plot produced by NADA web site (previous slide)

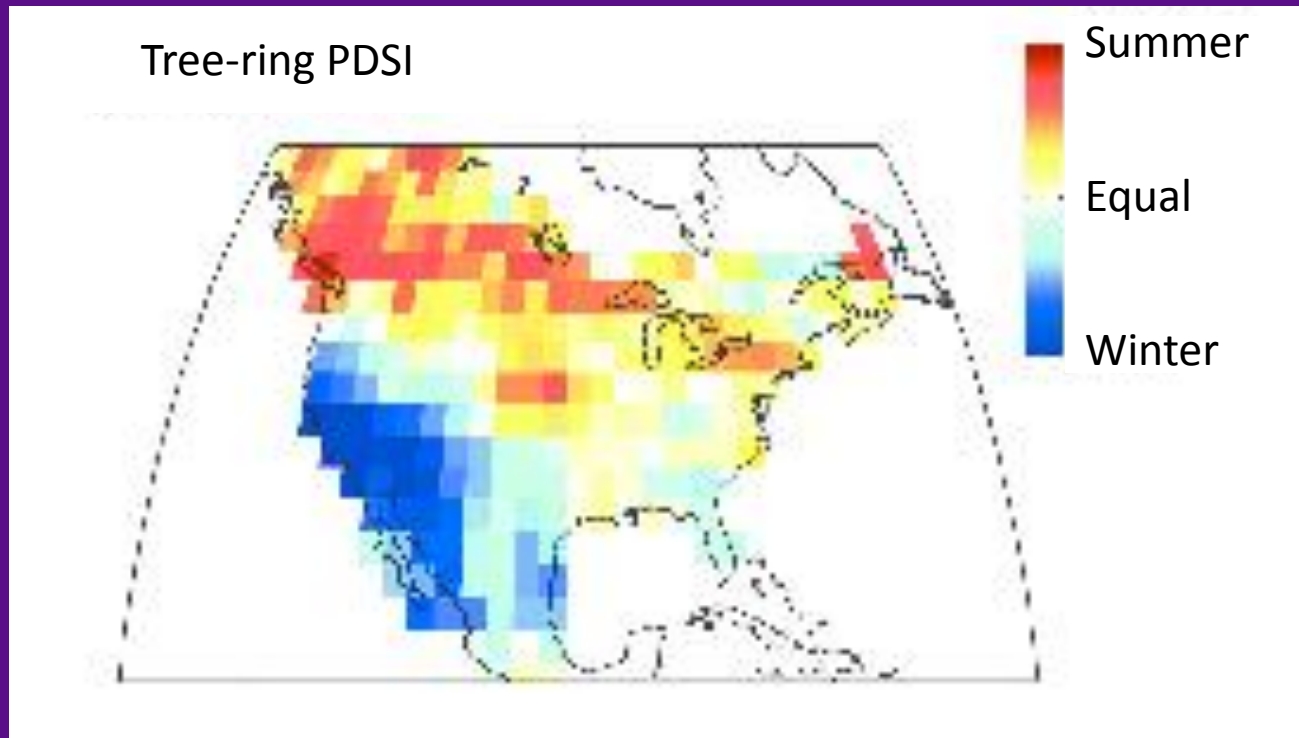
The NADA reconstruction for a given gridpoint might be based on distant tree-ring sites toward early part of tree-ring record



- Maps show chronologies available as POSSIBLE predictors in given year
- Fewer may actually enter model, depending on signal strength
- No local chronologies available at AD 1100

Chronology locations provided by Ed Cook (ref 4)

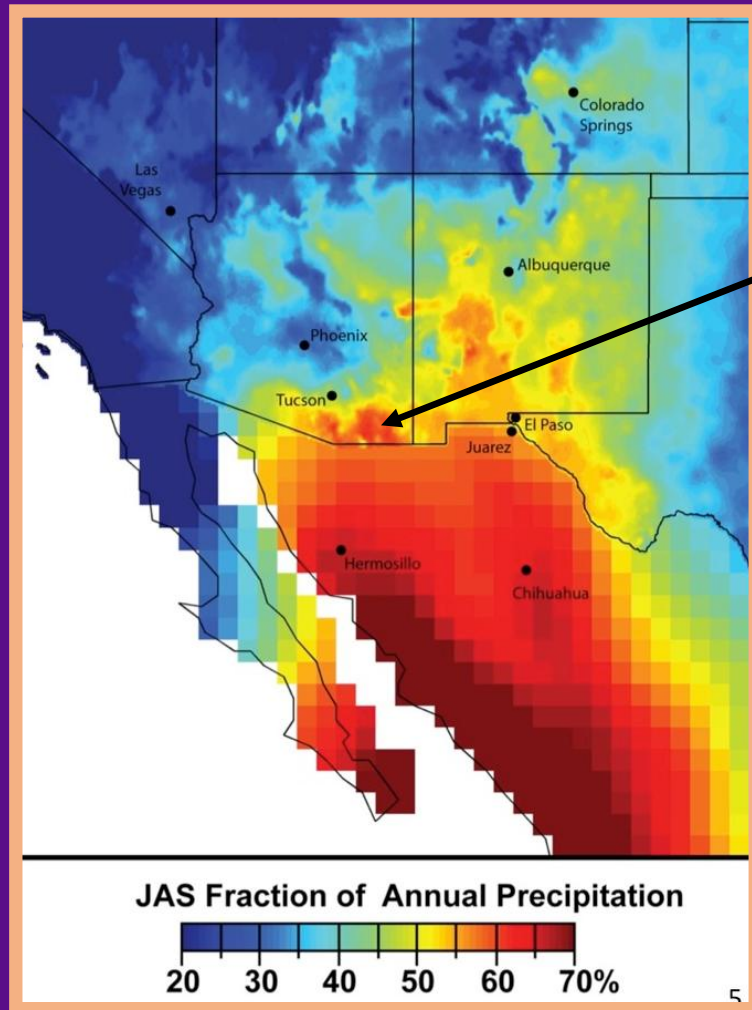
The NADA is reconstructed “summer” (JJA) PDSI, but in the Southwest those reconstructions reflect mainly **cool-season** drought



- Correlate reconstructed summer PSDI with
 1. Summer precipitation
 2. Winter precipitation
- Map the difference in correlation
- Analysis period 1901-1978

Figure from St. George et al. 2010 (ref 5)

The NADA largely misses the component of drought from failed summer monsoon – a critical limitation in SE Arizona



Southeast of Tucson, more than half the annual precipitation falls in June-September

- NSF project at UA 2008-2013
- Goal: seasonal precipitation reconstruction
- Primary tree-ring variable: sub-annual ring width

Figure from Dan Griffin (refs 6-7)

Sub-annual components can be identified. Measurements are related to seasonal precipitation anomalies

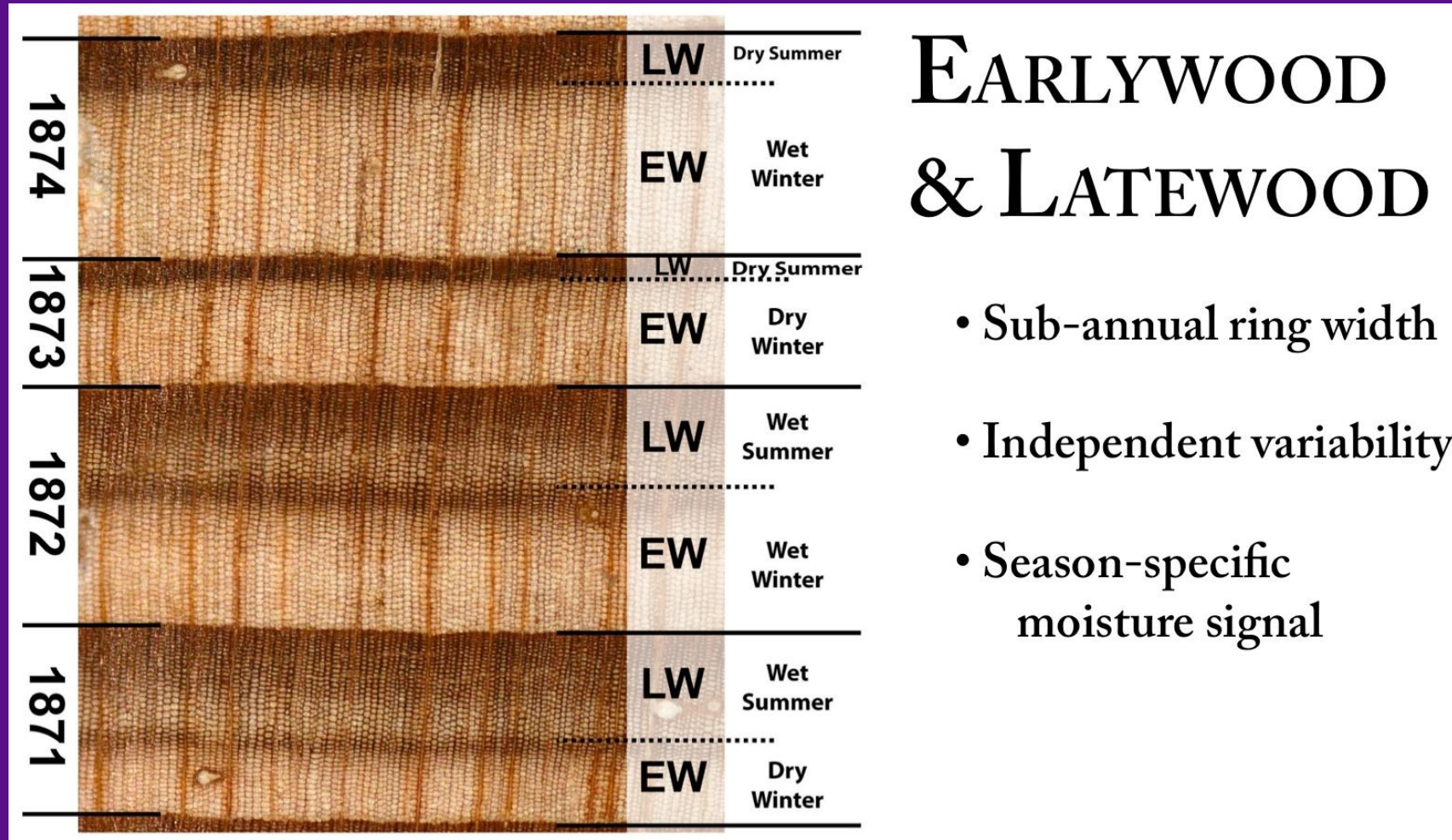
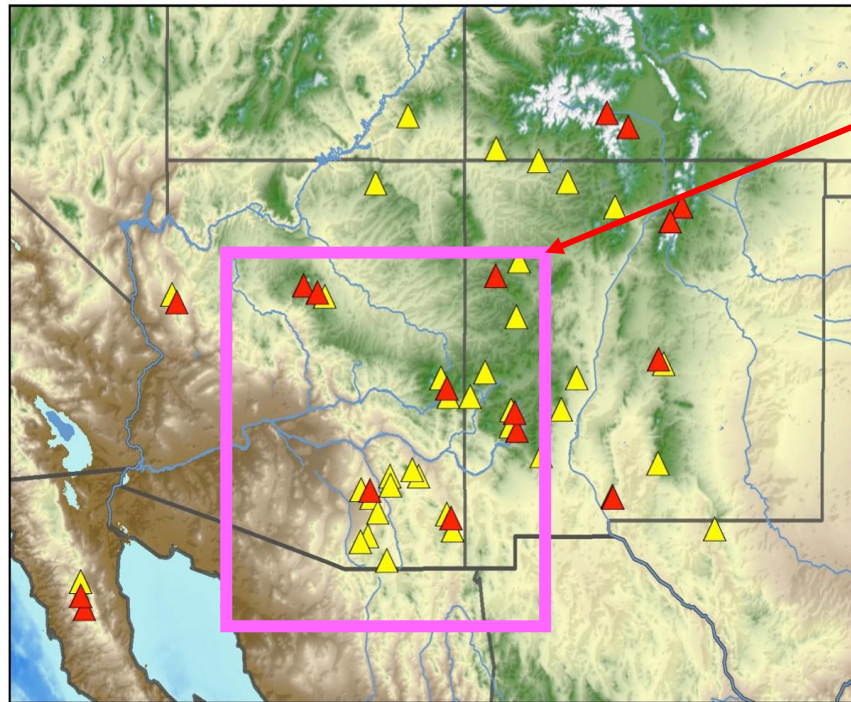


Figure from Dan Griffin (refs 6-7)

A network of tree-ring sites was collected and analyzed. Separate precipitation reconstructions were done for cool and warm season

LATEWOOD CHRONOLOGY NETWORK



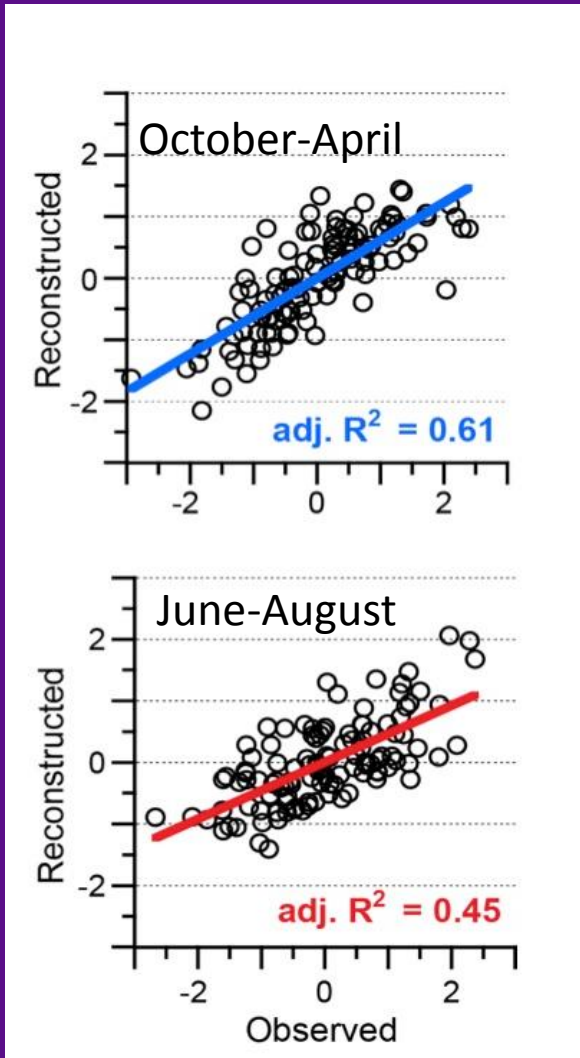
53 Sites
~2,200 Trees
948,077 Rings

▲ Douglas-fir, white fir ▲ ponderosa pine, other yellow pines

North American Monsoon Experiment (NAME) region 2

Figure modified from Dan Griffin (refs 6-7)

One finding was that sub-annual ring measurements can resolve seasonal precipitation anomalies in NAME region 2



- At left are scatterplots of reconstructed against observed seasonal standardized precipitation index (SPI)
- Cool season SPI is reconstructed from, earlywood width
- Summer SPI is reconstructed from latewood width

Figure from Dan Griffin (refs 6-7)

The big advance was for summer. Latewood-width allowed reconstruction of JJA (Monsoon) SPI back to the mid-1500s

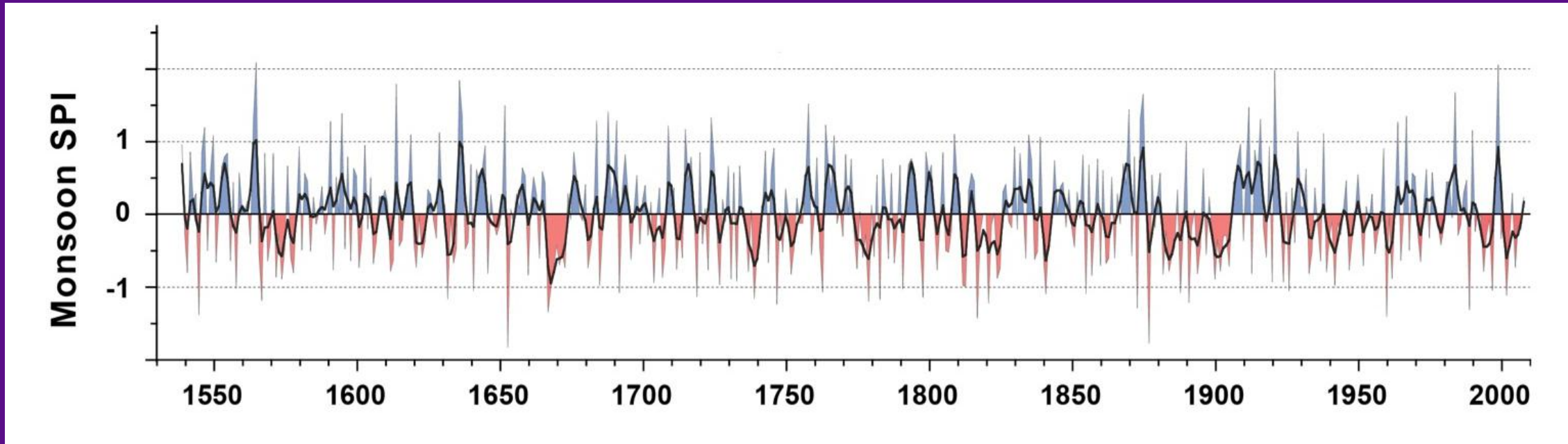


Figure from Dan Griffin (refs 6-7)

A strong feature of reconstructed monsoon SPI is the drought at the turn of the 20th century

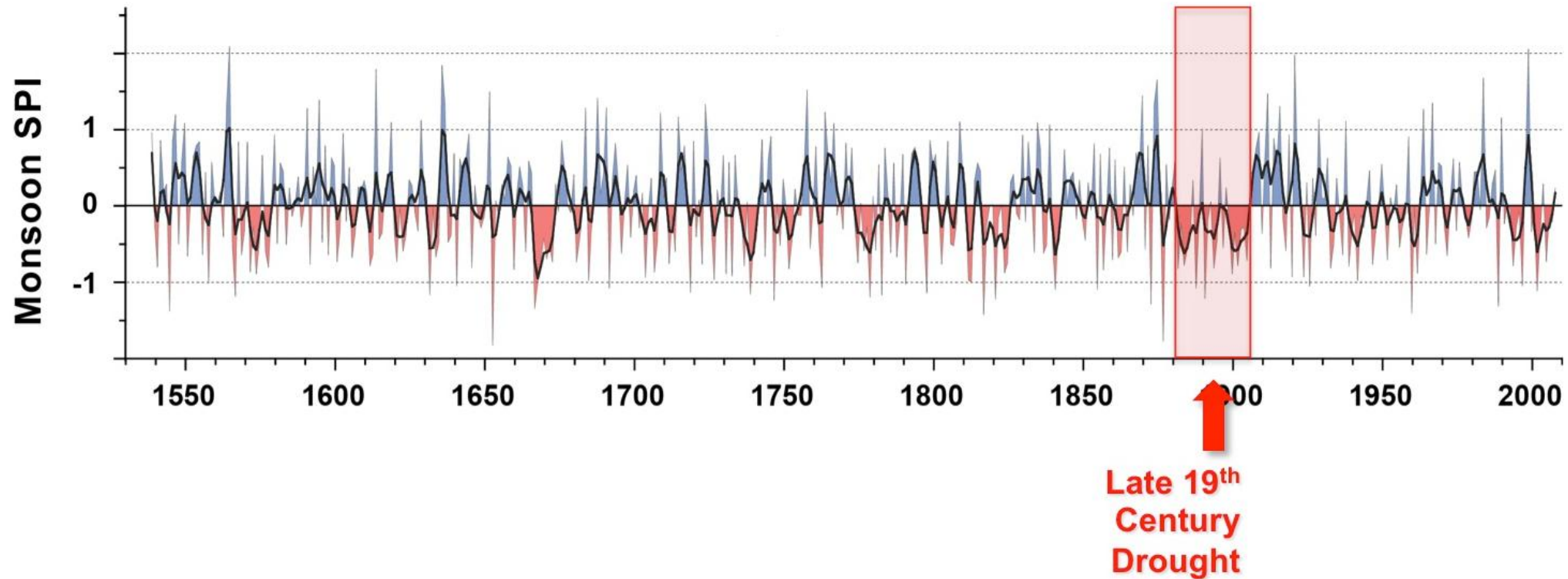


Figure from Dan Griffin (refs 6-7)

Results showed the cool season was also dry in the 1890s; 1904-1905 marked a sudden turn from drought to wetness.

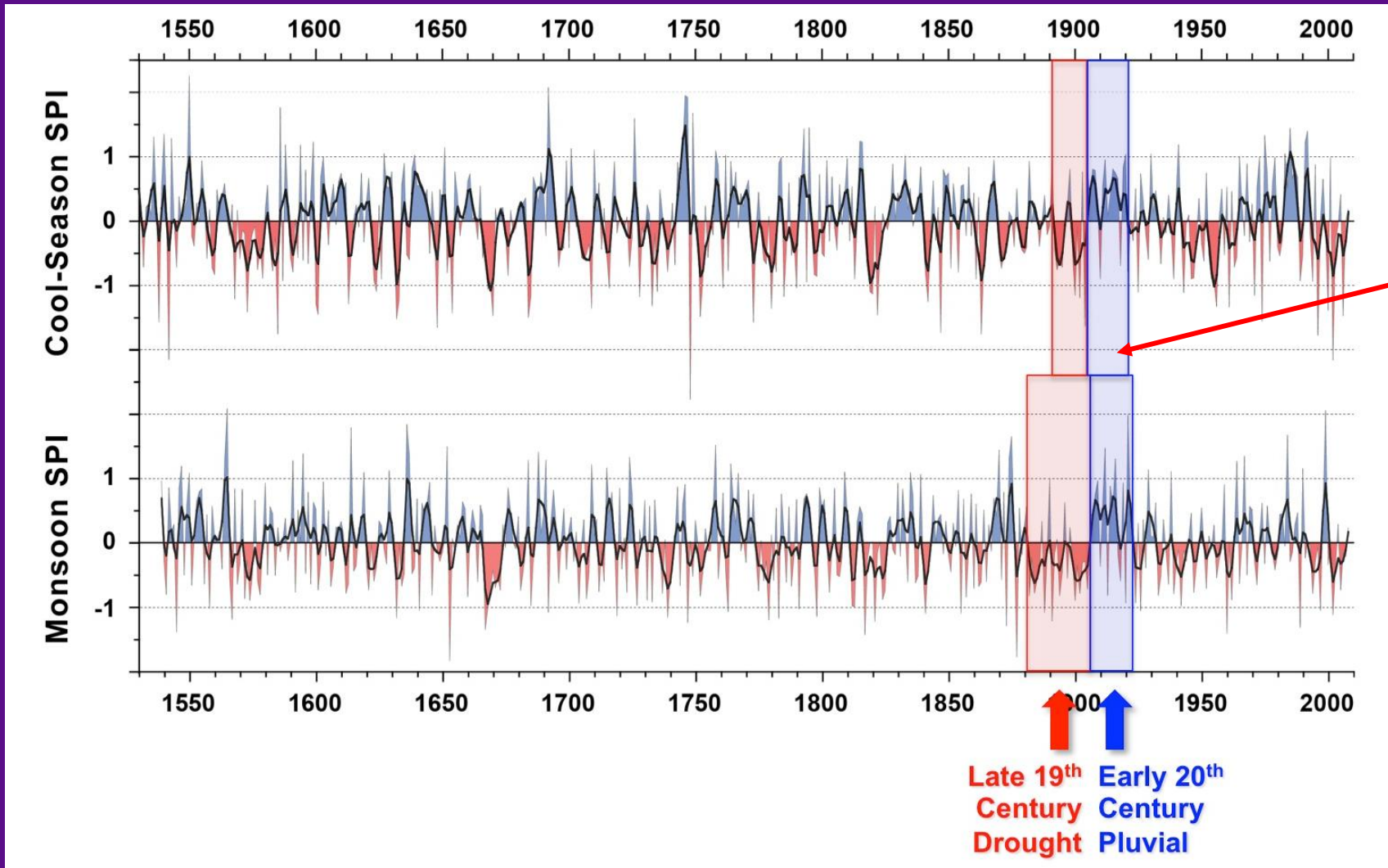


Figure from Dan Griffin (refs 6-7)

Future research topics relevant to SE Arizona

- Monsoon rainfall spatial variability
- Better separation of the seasonal precipitation signal
- Exploitation of the chemical properties in tree rings
- Riparian tree-ring signal



References

1. Meko, D. M., C. A. Woodhouse, C. H. Baisan, T. Knight, J. J. Lukas, M. K. Hughes, and M. W. Salzer (2007), Medieval drought in the Upper Colorado River Basin, *Geophys. Res. Lett.*, 34 (L10705), 10.1029/2007GL029,988.
2. Griffin, D., and K. J. Anchukaitis (2014), How unusual is the 2012-2014 california drought?, *Geophys. Res. Lett.*, 41 (24), 9017–9023, doi:10.1002/2014GL062433.
3. Belmecheri, S., F. Babst, E. R. Wahl, D. W. Stahle, and V. Trouet (2015), Multi-century evaluation of sierra nevada snowpack, *Nature Clim. Change*, 14 September 2015.
4. Cook, E. R., U. Lall, C. A. Woodhouse, and D. M. Meko (2008), North American Summer PDSI Reconstructions, Version 2a, wIGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series 2008-046, NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.
5. St. George, S., D. M. Meko., and E. R. Cook (2010), The seasonality of precipitation signal embedded within the North American Drought Atlas, *The Holocene*, 20 (6), 983–988, doi:10.1177/0959683610365937.
6. Griffin, D. 2013. Slides provided by Dan Griffin from dissertation presentation at Laboratory of Tree-Ring Research, University of Arizona, April 26, 2013.
7. Griffin, D., C. A. Woodhouse, D. M. Meko, D. W. Stahe, H. L. Faulstich, C. Carillo, R. Touchan, C. Castro, and S. Leavitt (2013), North American monsoon precipitation reconstructed from tree-ring latewood, *Geophys. Res. Lett.*, 40, 1–5, doi:10.1002/grl.50184.